



AMSAT – Past, Present and Future

An Update by Jan A. King, W3GEY

7th Australian Space Development Conference

July 15-17, 2002

AMSAT - Past, Present and
Future



Once Upon a Time, A Long Time Ago in a Land Called Oz...

1/9/2013

AMSAT - Past, Present and
Future



Some Students at the University of Melbourne Thought it would be Fun to Build a Satellite... and SO THEY DID. It had the first Amateur MUXed telemetry encoder and a real CMD system.

It was Harder Than They Thought but...

Eventually, They Finished it.

AMSAT - Past, Present and
Future



So They Sent the Spacecraft to America to be Launched -- Never to be Seen By Them Again. (Brave Lads, These).

But Alas, A Free Launch Could Not Be Found.

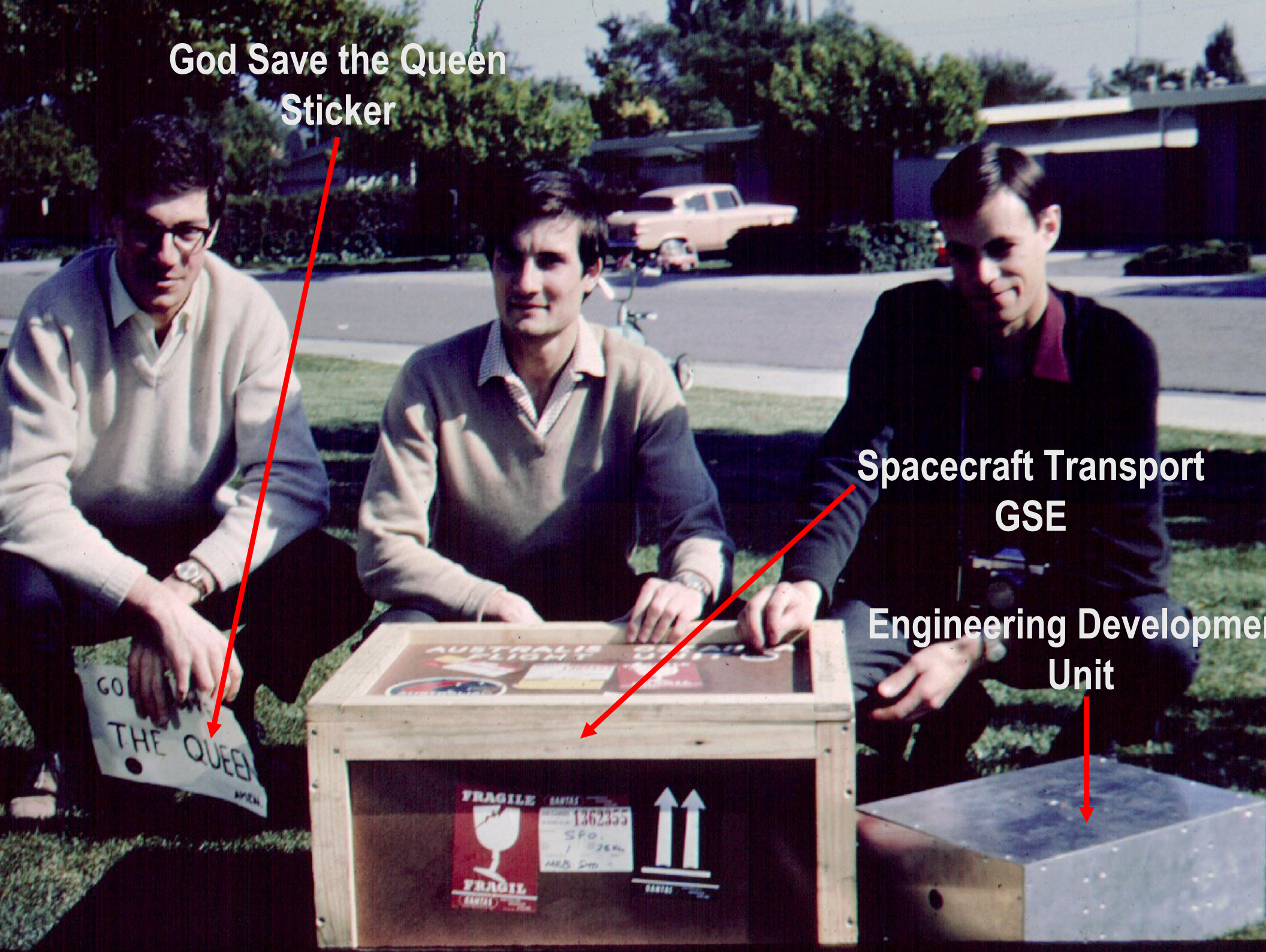
**So the Spacecraft Sat and Sat and Sat....
For Some Years.**

The Students Grew Up, Graduated and Moved Away. It was SAD...

**God Save the Queen
Sticker**

**Spacecraft Transport
GSE**

**Engineering Development
Unit**



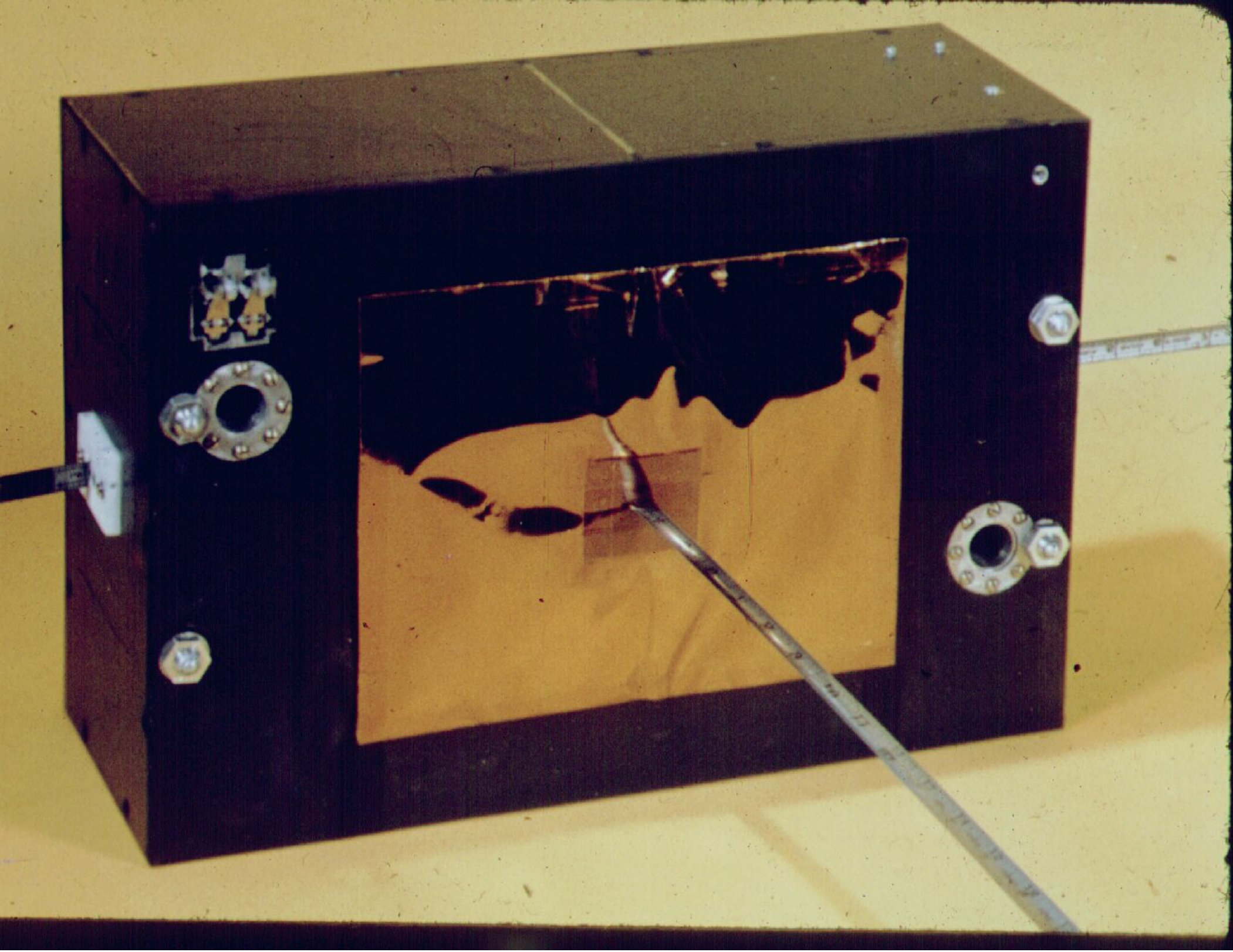


**... Until Some More Students Grew Up
and Graduated and Got a Job in the
American Space Industry.**

**They Remembered the Satellite From Oz
and Thought They Could Get it Launched
on One of NASA's New Delta Rockets.**

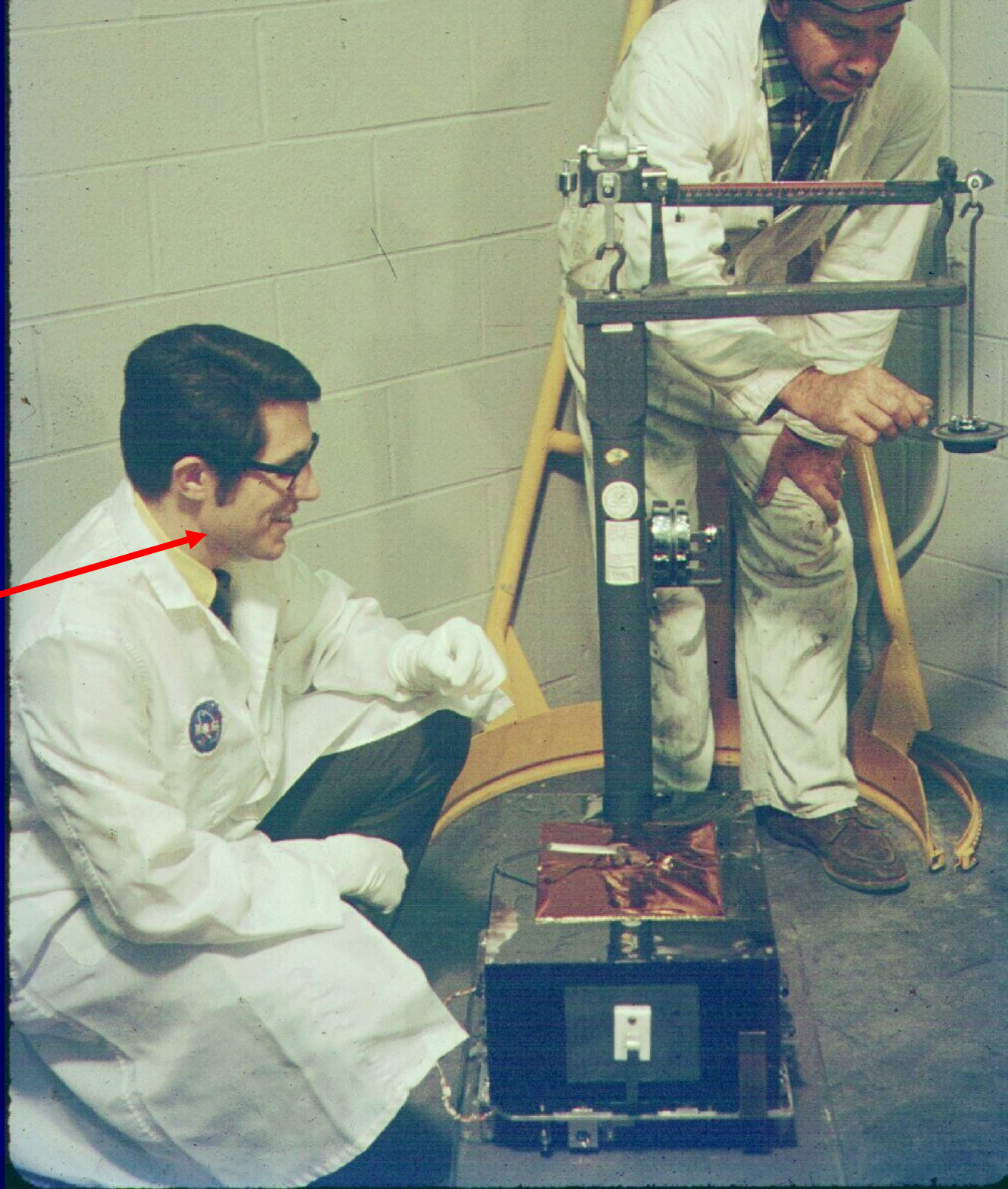
**They Contacted the Students from Oz and
Got the Spacecraft Ready for Launch.**







I'm Smiling Here
Because the NASA
Photographer Took
64 Shots of this
Same Scene.



1/9/2013

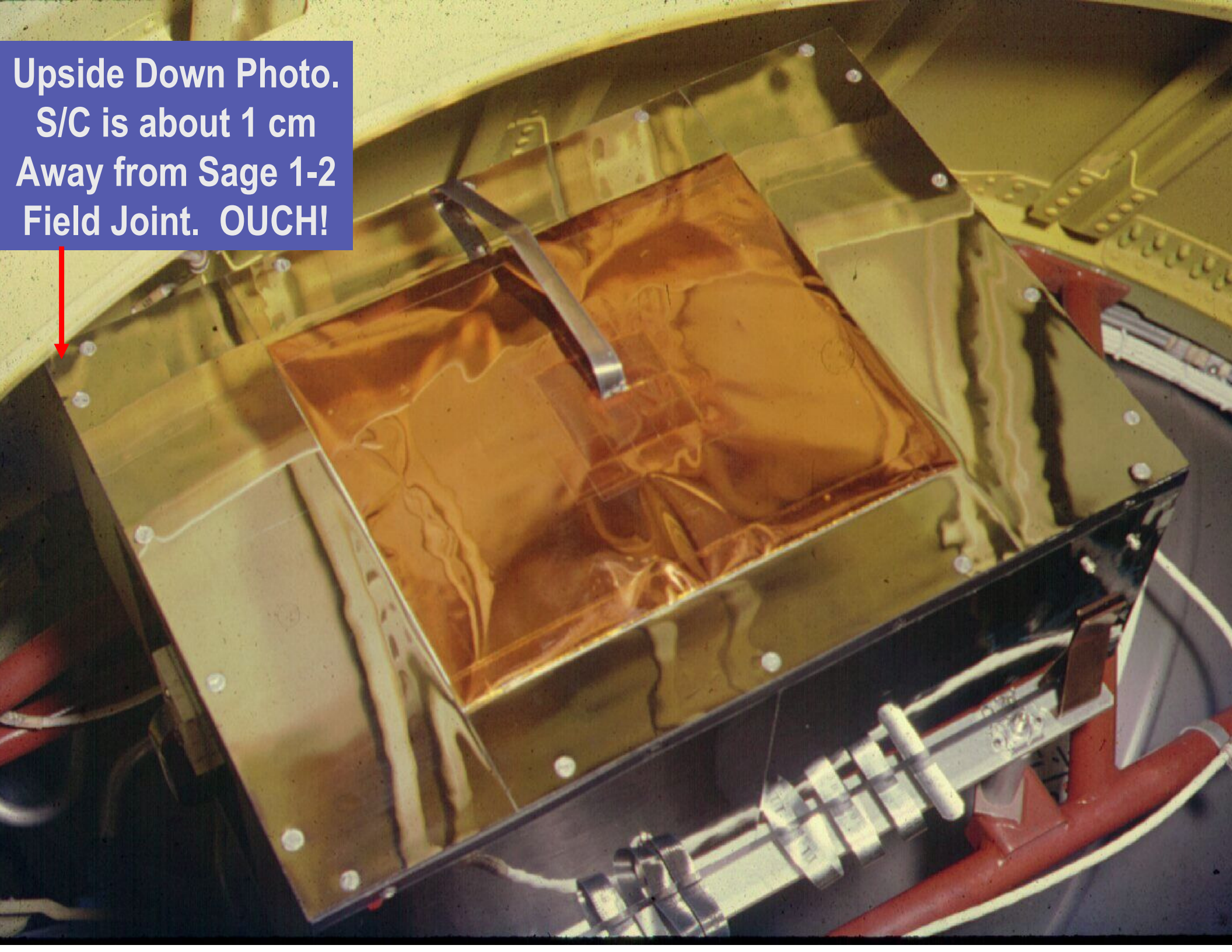


LATE 1969

Australis-OSCAR-5 S/C

This Spacecraft was Mated to the
Aft End Of the Second Stage. Not a
Very Nice Spot to be BUT it got up
there.

Upside Down Photo.
S/C is about 1 cm
Away from Sage 1-2
Field Joint. OUCH!





And.....So They Got it Launched. The Launch was Successful.

And the Satellite from Oz Worked Very Well.

Everyone Learned Heaps.

And Everyone Was Pretty Darn Happy!

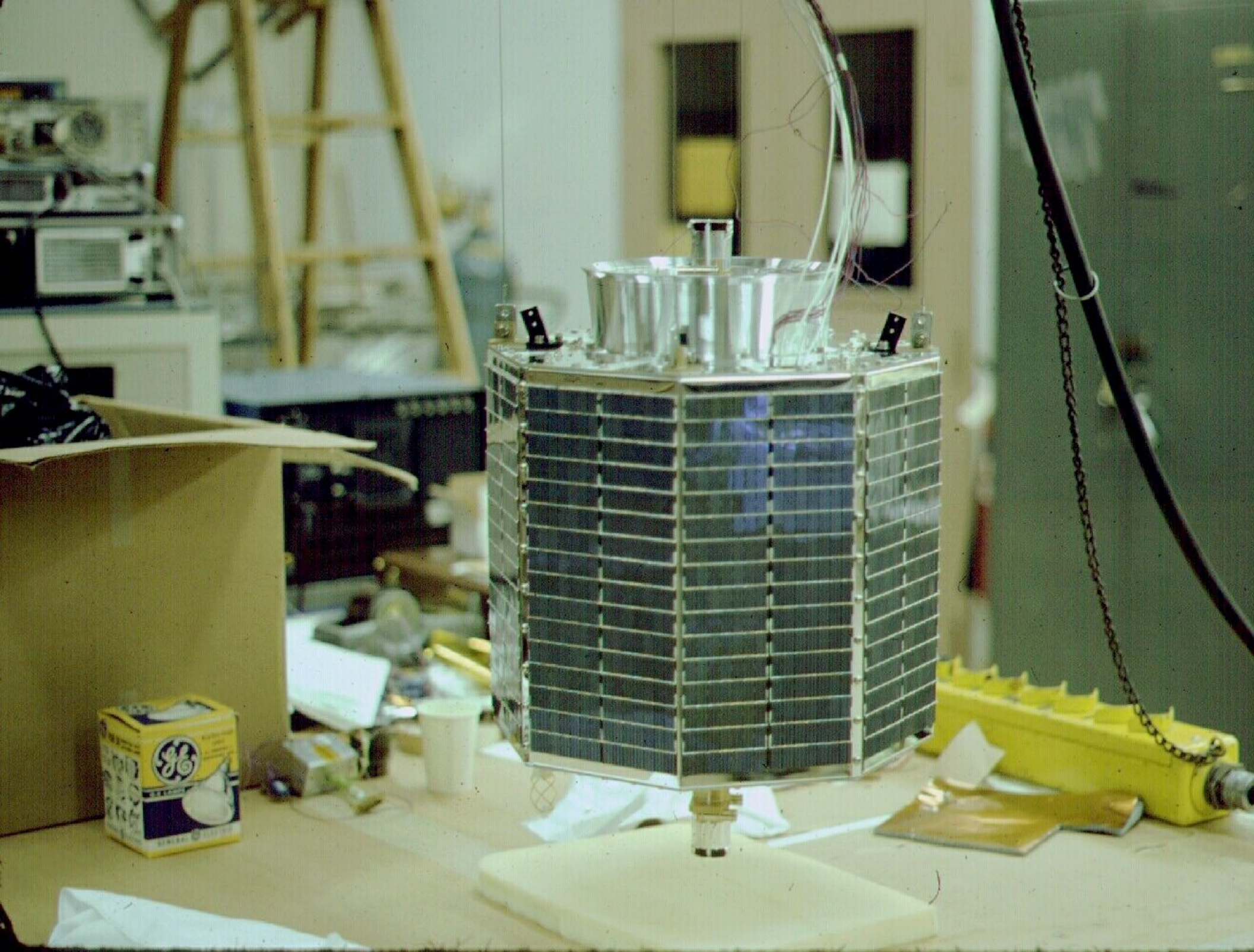
And a New International Pastime Was Born. – Building Spacecraft for **FUN and for **LEARNING** but, NOT for Profit.**

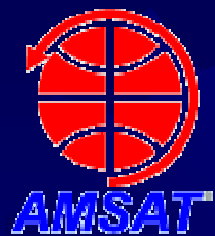


**So, More and Better Satellites Were
Built this Way... All Around The
World.**



Small Satellites . . .

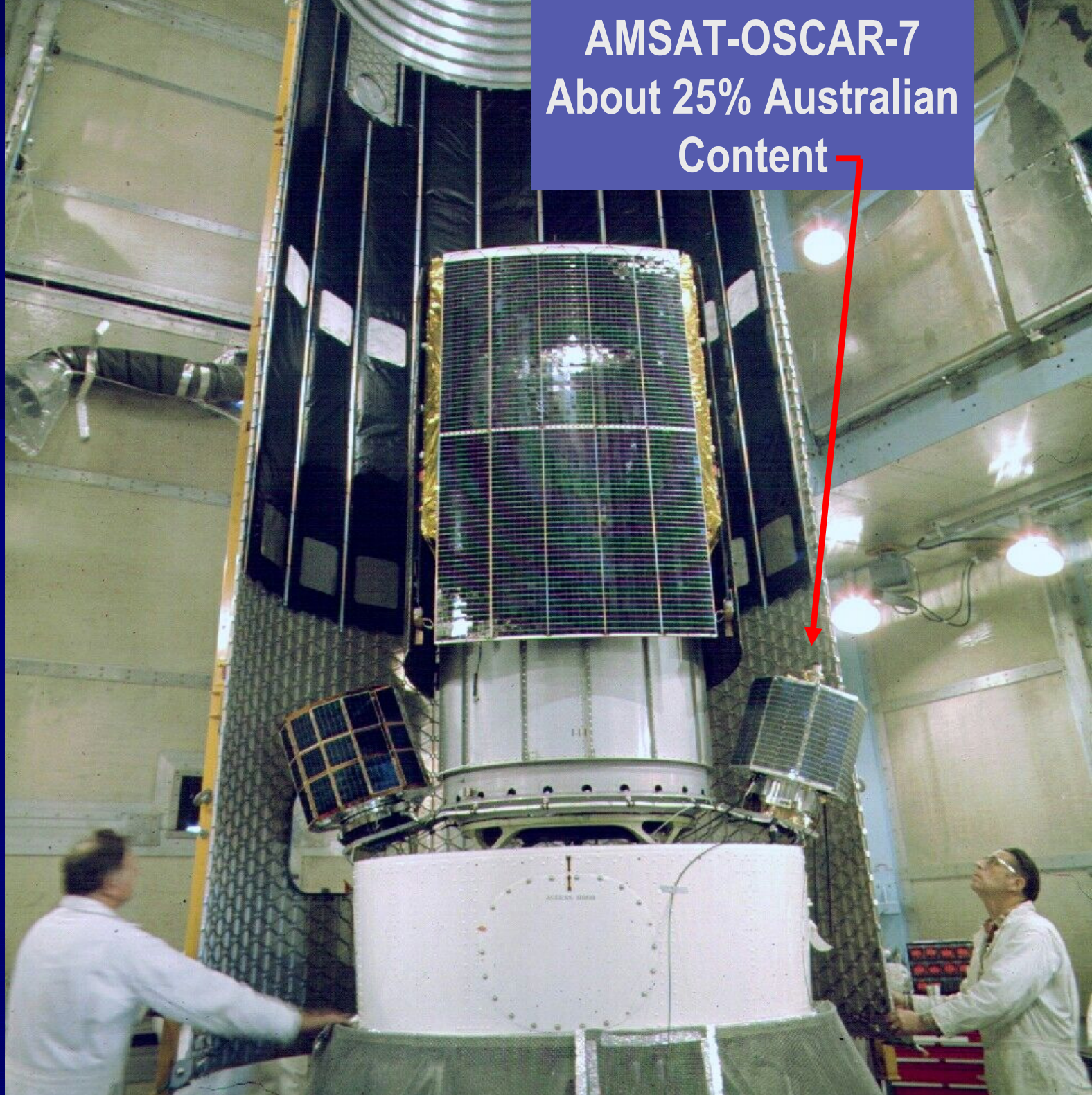




LATE 1974

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AMSAT-OSCAR-7
About 25% Australian
Content





And Medium Sized Satellites. . .



AMSAT-OSCAR-13
MID 1988





Scientific and Educational Spacecraft. . .

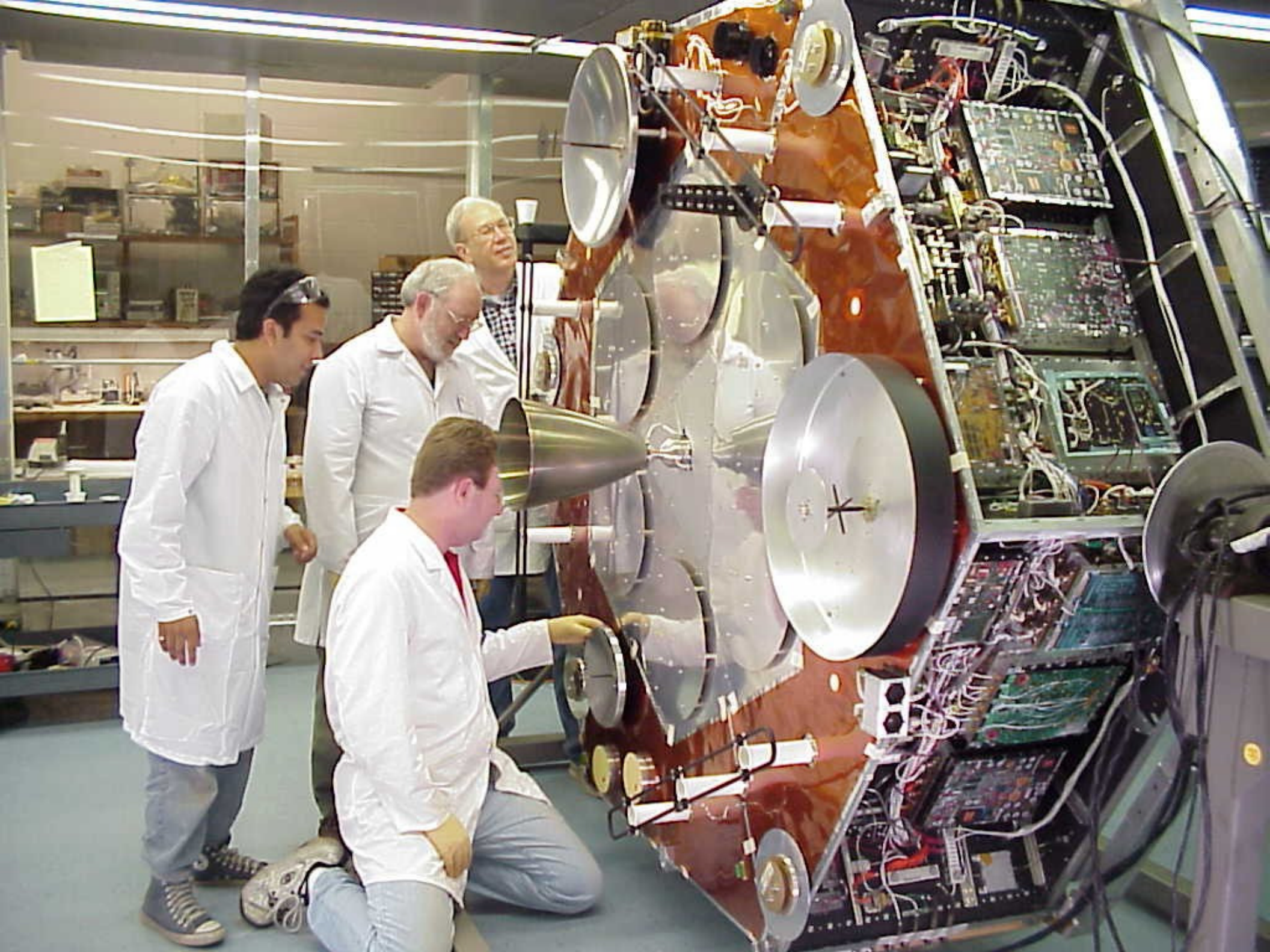
UoSAT-OSCAR-9

Late 1981

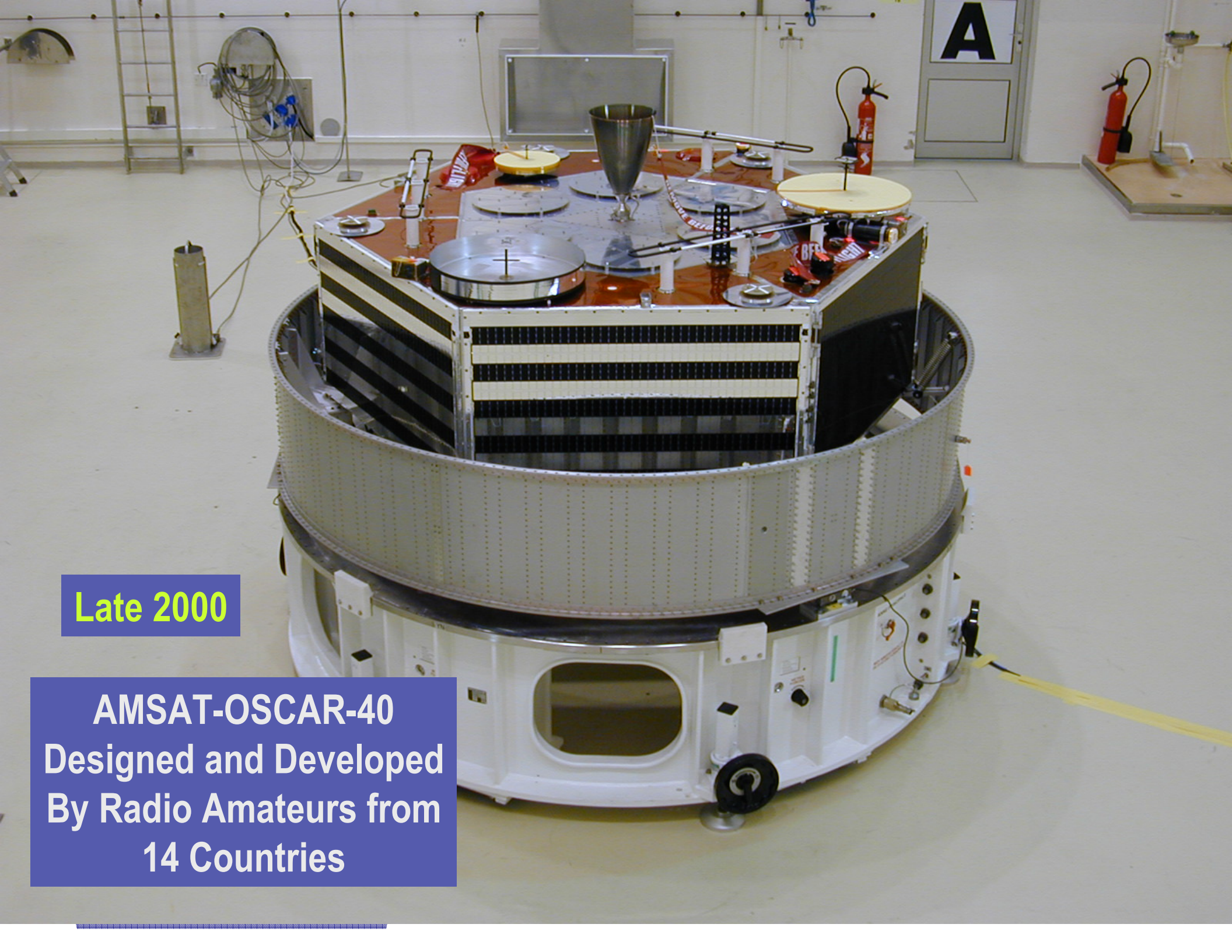




And Even Pretty Big Satellites. . .





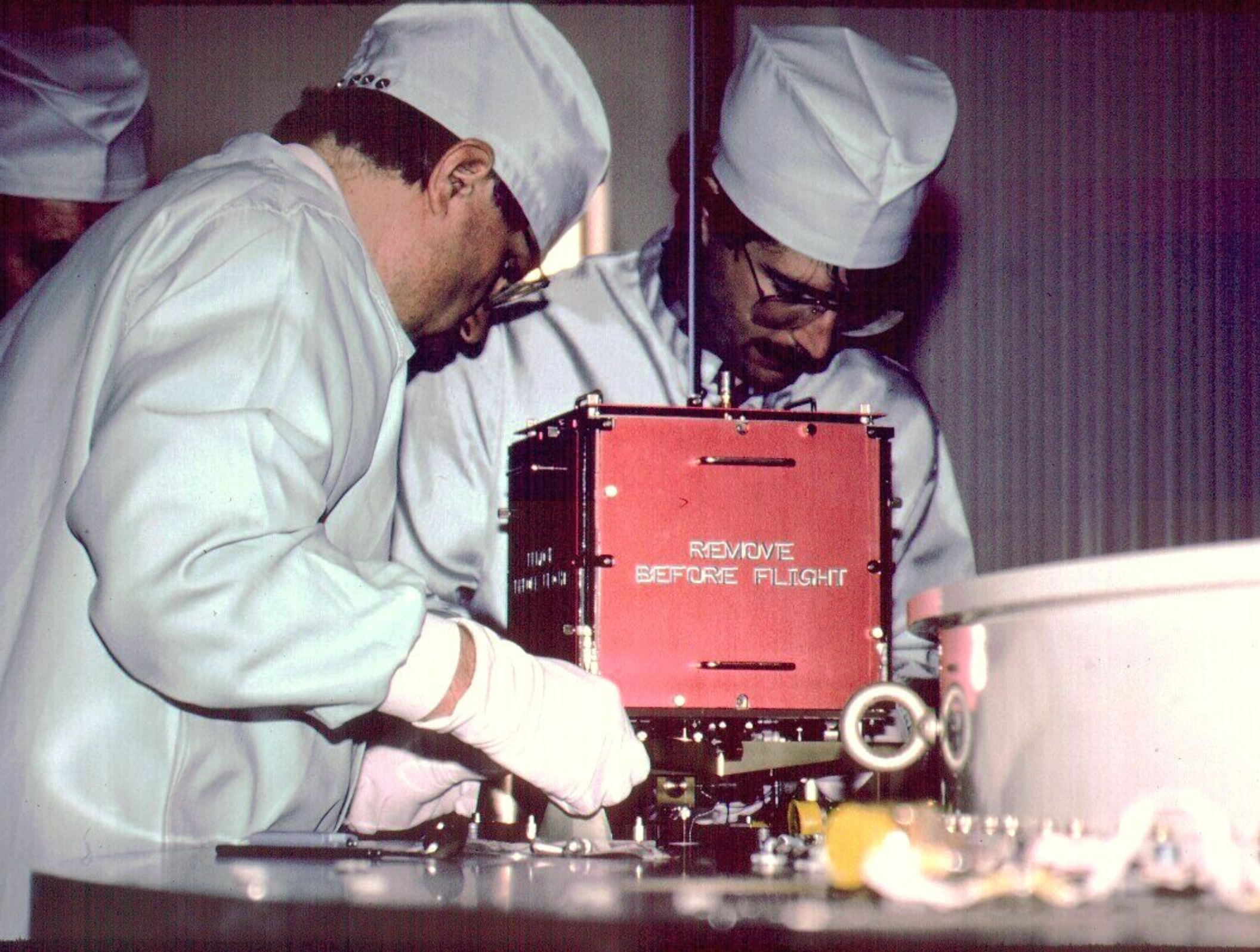
A photograph of the AMSAT-OSCAR-40 satellite in a laboratory setting. The satellite is a cylindrical structure with a white base and a silver, perforated middle section. The top is a red platform with various instruments, including a large metal funnel, a yellow circular component, and a silver circular component. A red fire extinguisher is visible in the background. A door with a large 'A' is also visible. The satellite is connected to various cables and equipment.

Late 2000

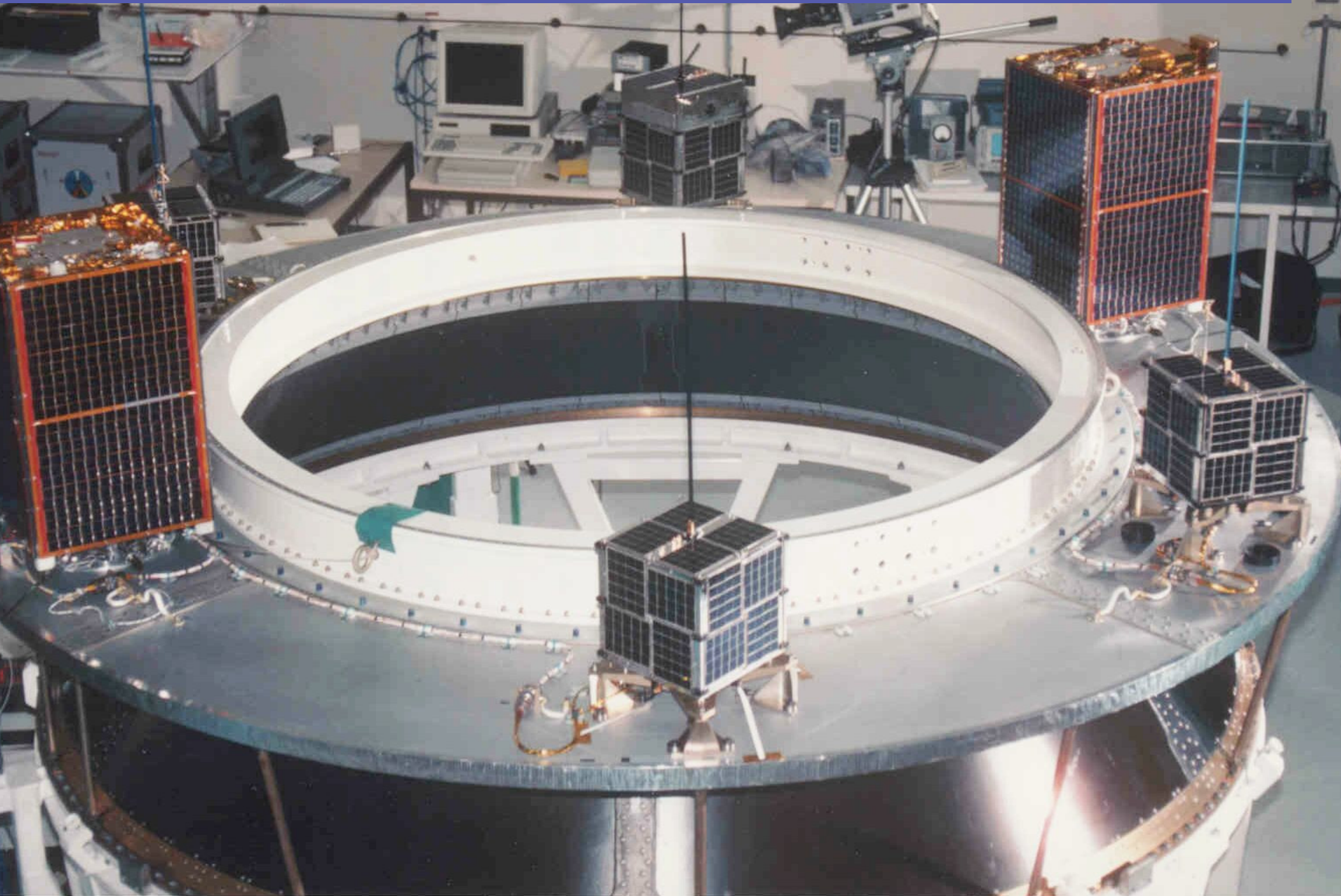
AMSAT-OSCAR-40
Designed and Developed
By Radio Amateurs from
14 Countries



**And Even a Group of Four Very
Small Satellites Making Up an Mini-
Constellation of Communications
Satellites.**



Four AMSAT MicroSats Seen Here with Two Second Generation UoSATs All Carried on the First Ariane-4 ASAP Ring



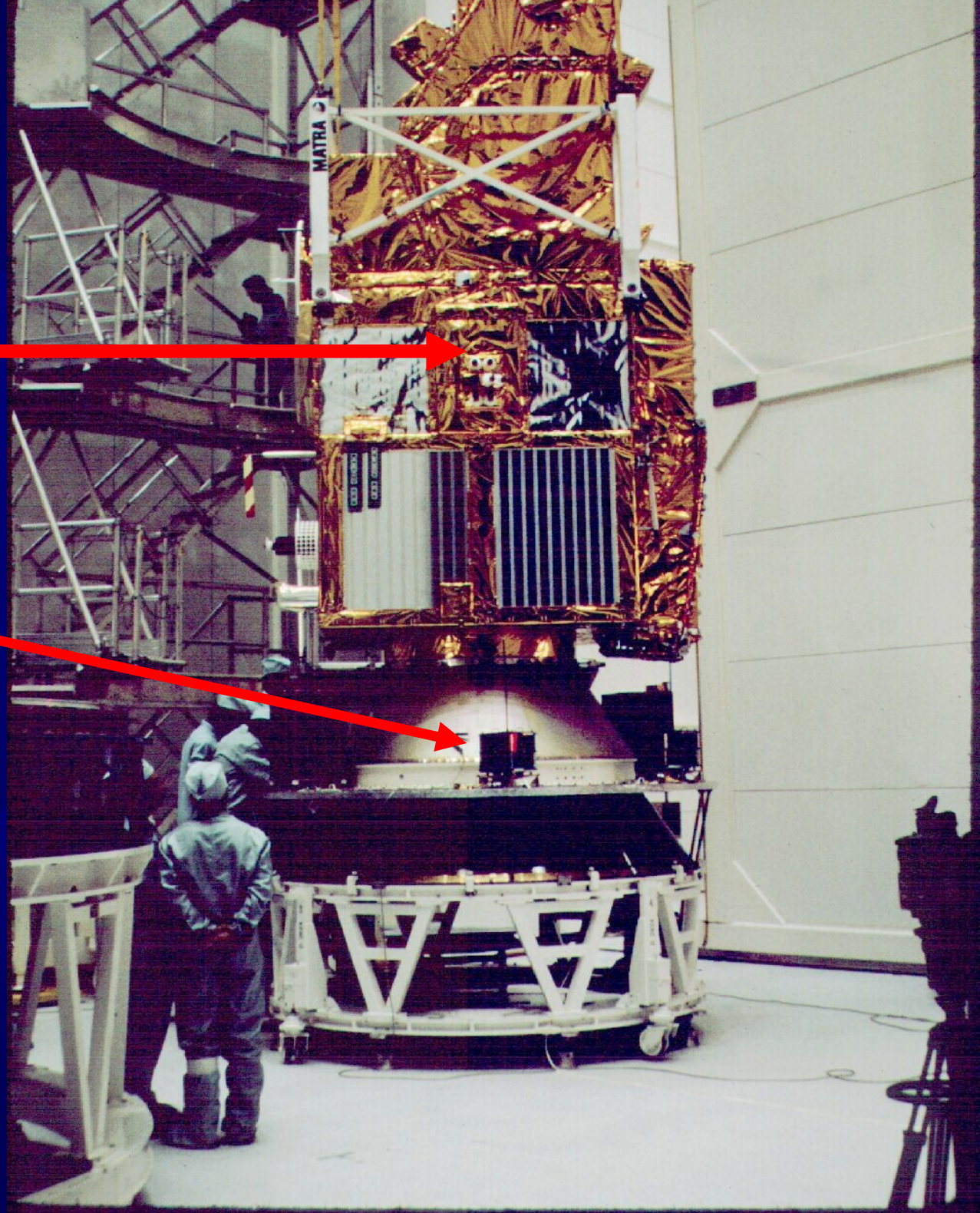


SPOT-2

MicroSat

Early 1990

1/9/2013





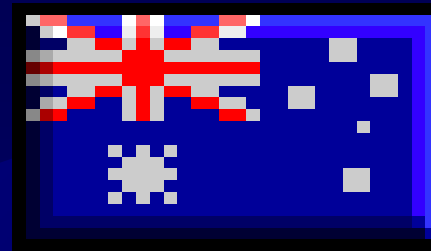
**Which Only Goes to Show: To Develop a
Spacecraft, You Don't Necessarily Need a
Lot of Money.**

BUT...

**It Does Seem to Require Passion, Drive
and Motivation. . . AND a Little Luck.**



AMSAT-NA



Thanks Australia

**For Your Many Important
Contributions to the
Amateur Satellite Program.
*Without You We Might Never Have
Been!***



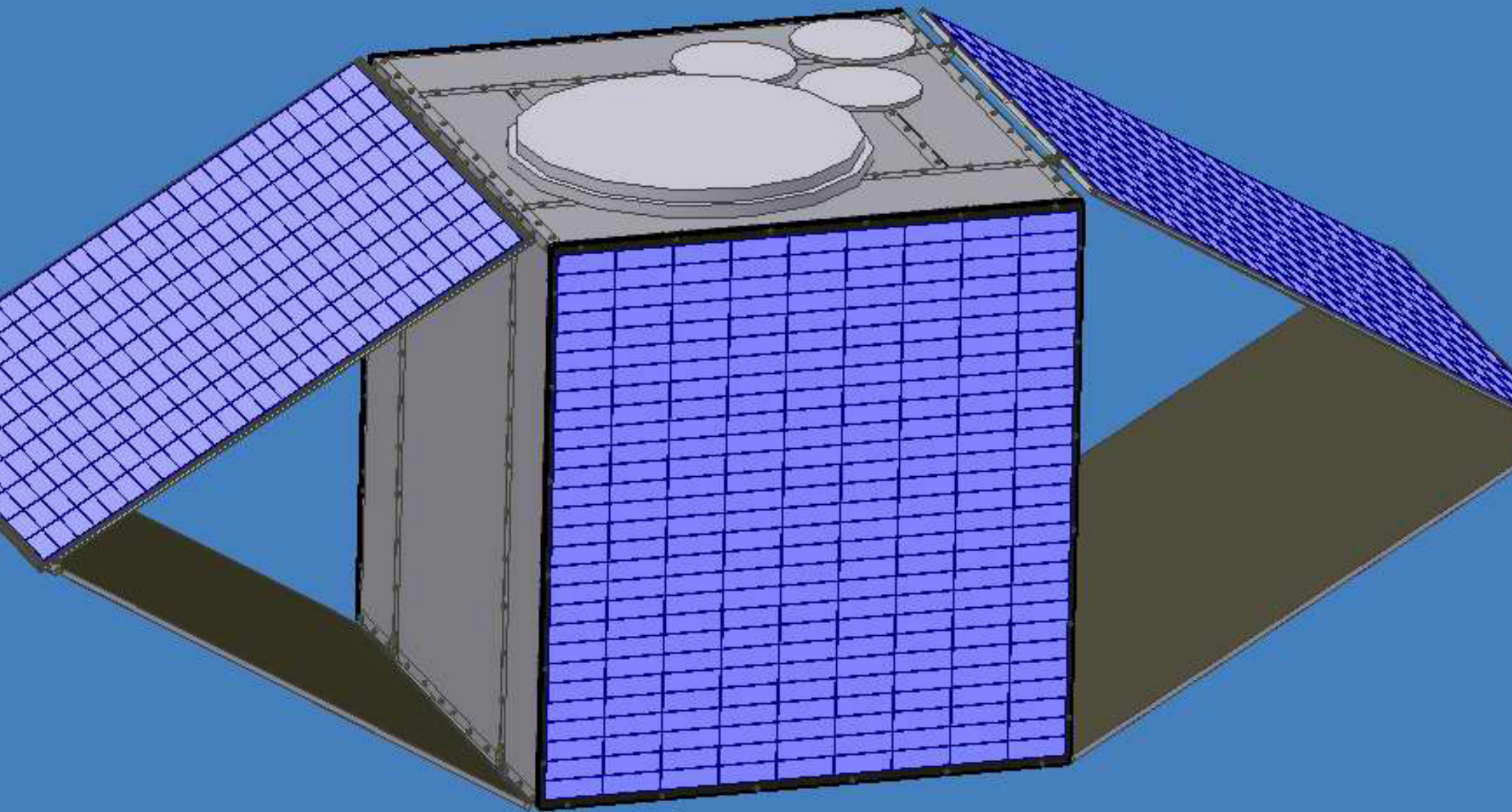
NEW PROGRAM INITIATIVES



AMSAT-NA EAGLE

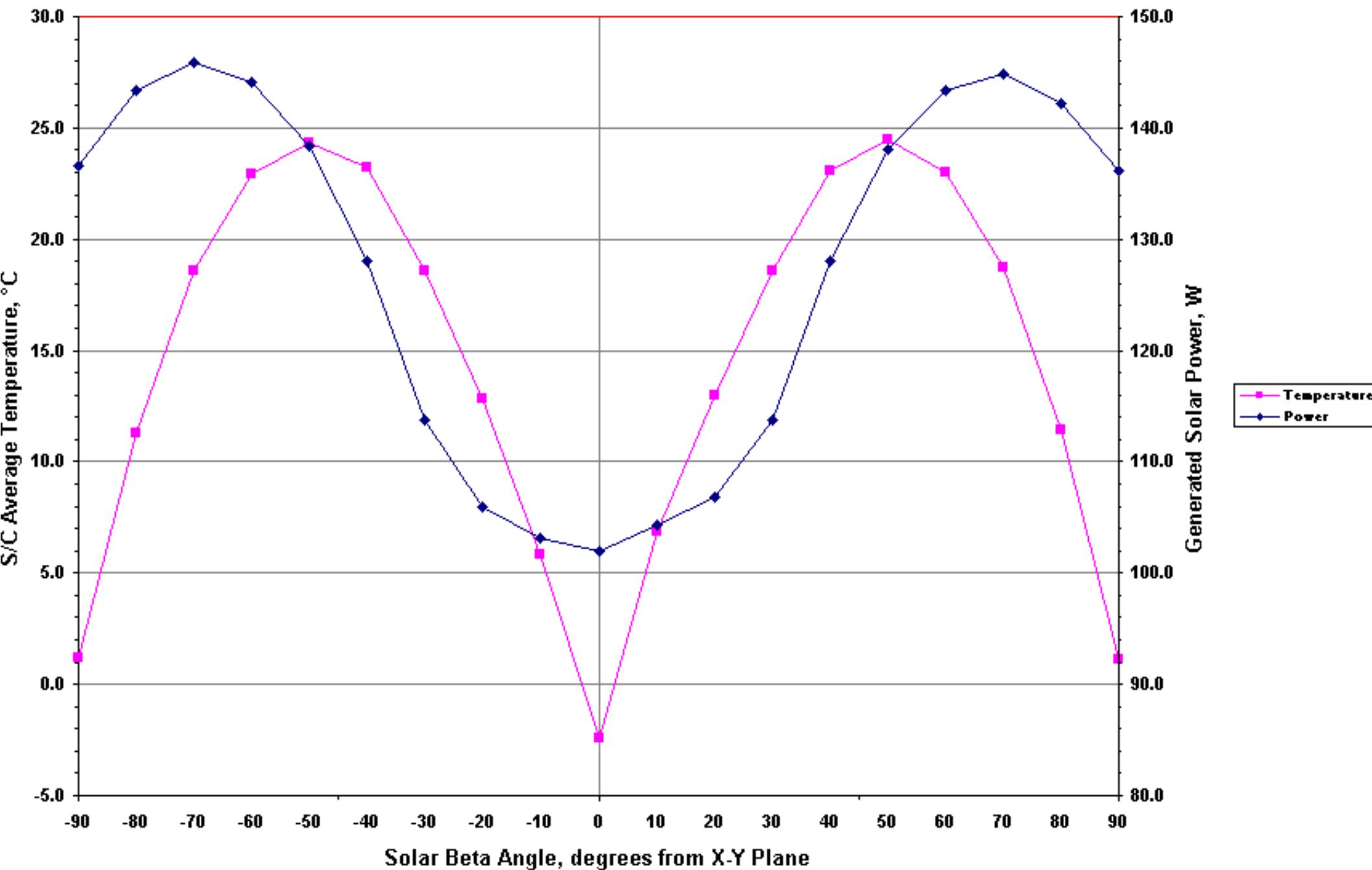
A Second Generation, Mid-Sized HEO Orbiter

Pointing at Apogee
Mass Class
Power Class
HF/L-Band/S-Band



P3E Thermal Analysis

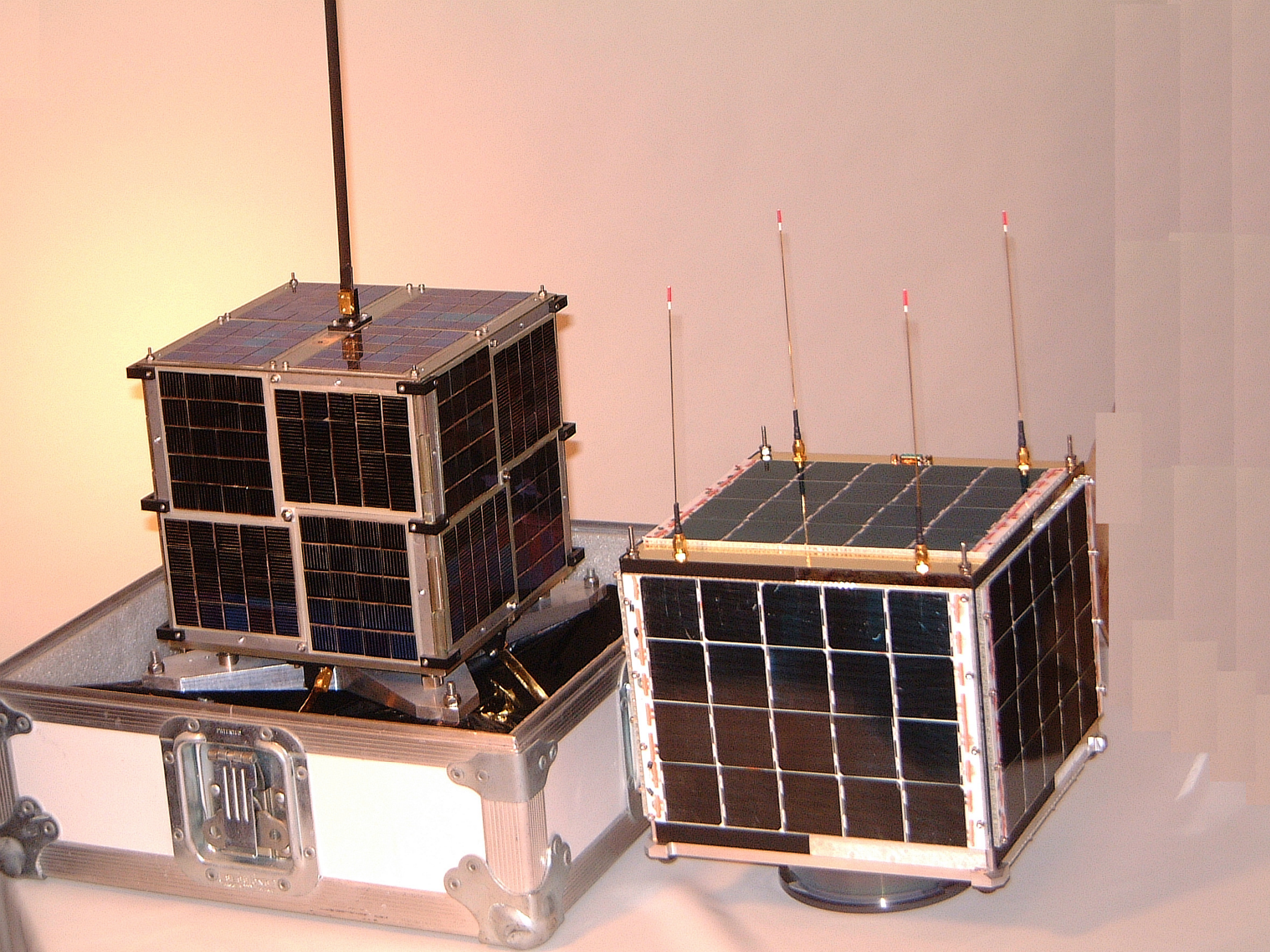
Preliminary Design, Model: P3E-1.002





AMSAT-OSCAR-E

A Next Generation Nano-Satellite





Advanced Data Communications for the Amateur Radio Service (ADCARS)

Apply digital encoding techniques to improve communication links and bandwidth utilization.

Wide-band TDMA single frequency data link for multiple simultaneous users and modes.

- voice, data, video, telemetry, etc.

S-band downlink, due to bandwidth requirements.

L-band uplink.

Optional signal regeneration.

Optional integration with on-board systems.

- File transfer
- Telemetry
- Data communication
- MPEG recordings

$$C = B \log_2 \left(1 + \frac{S}{N} \right)$$

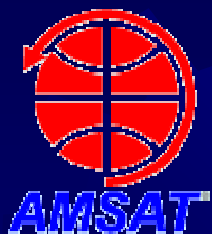
Channel capacity:

where:

C = channel capacity,
bits/sec

B = channel bandwidth,
Hz

S = signal power, W



Robust Telemetry Link

A Design Example

Demonstrate the value of using FEC and interleaving to improve telemetry reception by ground stations.

★ Encoding and Interleaving

- Reed-Soloman + Interleaver + Convolutional Encoder, as proposed by KA9Q for AO-40.
- Supports worst case operations.
- Provides link gain.

★ Possible link designs

- 9600 baud FSK, as implemented in the Kenwood TM-D700A and TH-D7AG so that APRS UI frames can be interspersed with the telemetry.
- 56K bps GMSK for max throughput.
- There is no possibility of 1200 bps AFSK on this satellite.

★ AO-E Architecture Constraints

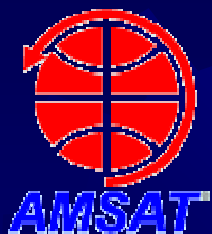
- All data goes to an NEC 72001 SCC.
- Then to an FPGA shaping circuit.
- Then to the varactor modulator.
- Data rates from 600 to 64K baud.

★ Design Flexibility

- Full control over the SCC.
- Some control over shaping in FPGA.
- Can adjust the amplitude and offset of signal to varactor.

★ Implementation

- Software in IHU.
- Hardware + Firmware (PIC?).



FLASH!! FLASH!! AMSAT-OSCAR-7 Returns from Dead

- ★ On June 21, 2002 at 1728 UTC Signals Were Heard from AO-7 on it's normal VHF Beacon Frequency.
- ★ It's NiCD Battery has FAILED Again. This time OPEN.
- ★ S/C Runs on Solar Power Only and is OFF in Eclipse.
- ★ Everything Checked So Far Still Works:
 - ★ Primary Telemetry System
 - ★ Both Communications Transponders
 - ★ UHF Beacon
 - ★ Command System



Now That It's Back:

- ★ **It is the Oldest Working Amateur Satellite**
- ★ **It has the Oldest Working CMOS Logic in Space**
 - **Logic has Survived 2.5 Solar Cycles!**
 - **125,000+ Orbits; 1460 km Altitude, Sun Synchronous Orbit**
 - **Estimated Total Dose: >100 kRads**
- ★ **It's Being Used by Hundreds of People for Communications.**

I'm Back!

AO-7

- Launched: Nov. 1974
- Died: June 1981
- Born Again: June 2002





Mars Atmospheric Constellation Observatory (MACO)

- ★ Mission to be Proposed as a Mars Scout Mission
- ★ JPL, University of Arizona, et al. looking for teaming partner for micro-satellite development.
- ★ International Partner Preferred
- ★ Development Expected to be Funded by Host Country



Mars Atmospheric Constellation Observatory (MACO)

★ Science Objectives at Mars:

● Atmospheric Water Concentration

- 2 - 10 % Accuracy
- 0.1 - 1.0 km Resolution
- 0 – 60 km Altitude

● Temperature

- Sub-Kelvin Accuracy
- 0.1 – 0.4 km Resolution
- 0 – 80 km Altitude

● CO2 Density

- 0.1 % Accuracy
- 0.1 – 0.4 km Resolution
- 0 – 80 km Altitude

● Winds

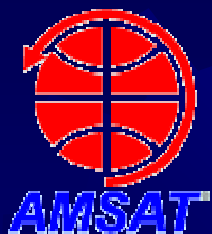
- 1.5 m/sec Accuracy
- 0 – 80 km Altitude



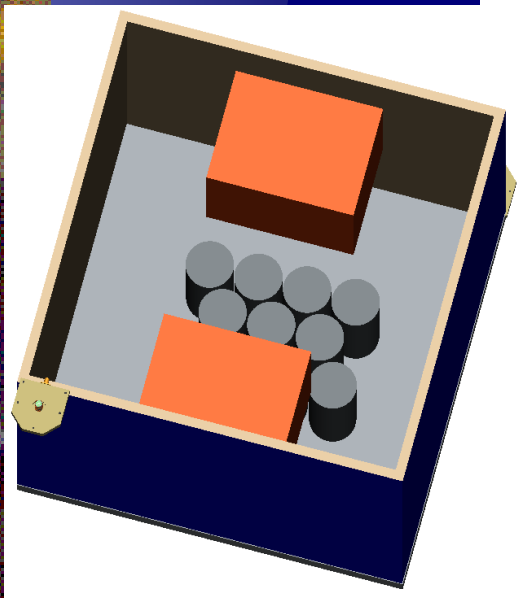
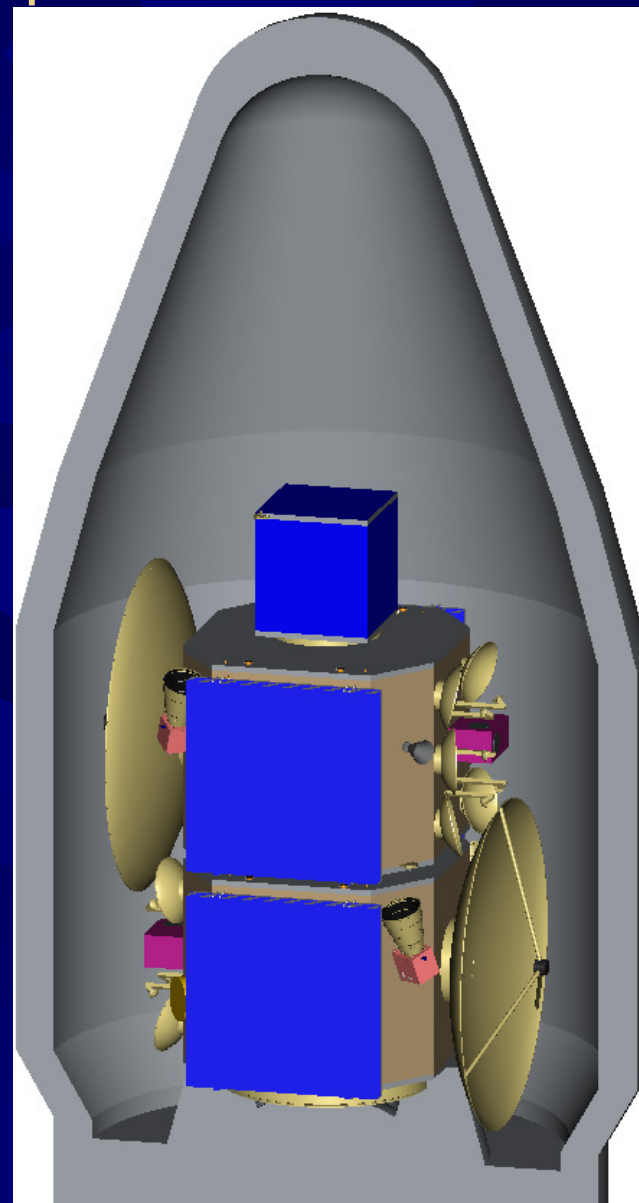
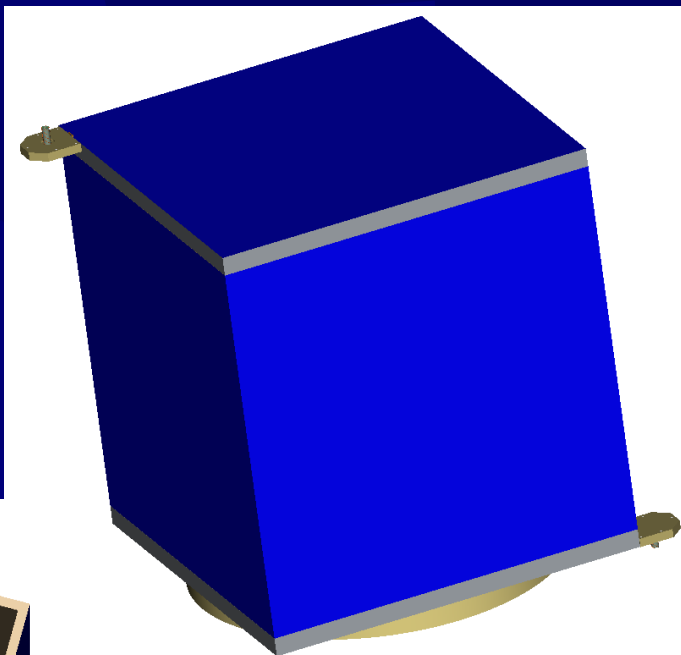
Mars Atmospheric Constellation Observatory (MACO)

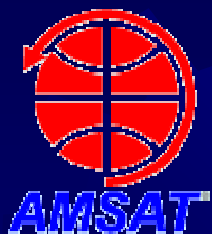
★ Systems Approach

- Mini-Constellation of 3 – 4 Spacecraft
- Two Larger and 1 – 2 Micro-satellites (acting as Beacons)
- Radio Occultation Measurement Techniques
 - Active measurement between two large S/C at 183 GHz
 - Active measurement between large and micro at 8.5 GHz
- Passive Radiometer Measurements at 183 GHz
 - This frequency is a sensitive water absorption line



“Beacon” Spacecraft Option





MACO Secondary Payload Power Requirements

SOLAR ENERGY

Solar Constant, Earth:	1370.0 W/m ²
Mars distance:	1.4 AU
Solar Constant Mars:	699.0 W/m ²

Xmit radiated power:	2.0 W	At 8500 MHz
Efficiency:	50%	"
Transmitter D.C. Power:	4.0 W	"

Power budget

USO power:	2 W
Transmitter power:	4 W
Exciter:	1 W
Thermal control:	2 W
Battery controller:	0.5 W
TOTAL:	9.5 W
Power supply inefficiency	30%
TOTAL, w/inefficiencies:	12.35 Watts

Solar panel efficiency:	20%
Time in eclipse:	30%

DIMENSIONS

Surface area required:	0.1262 m ²	
Spacecraft size:	0.355 m	One dimension of cube
	13.99 inches	



“Cubesats” or Pico Satellites

- ★ 4“ or 10 cm Cubic Satellite Structures**
- ★ 1 – 2 kg Total Mass**
- ★ Injected as Secondary Payloads into (Very) Low Earth Orbit**
- ★ Launch Cost: \$35K to \$50K USD**
- ★ Over 20 Universities World-Wide Developing These S/C**